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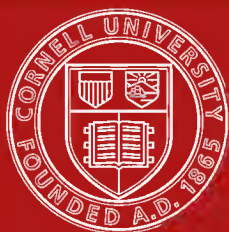
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**Explanation of sheet 7. Ayrshire; southwe**



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**Memoirs of the Geological Survey,  
SCOTLAND.**

**EXPLANATION OF SHEET  
7.**

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**AYRSHIRE: SOUTH-WESTERN DISTRICT.**

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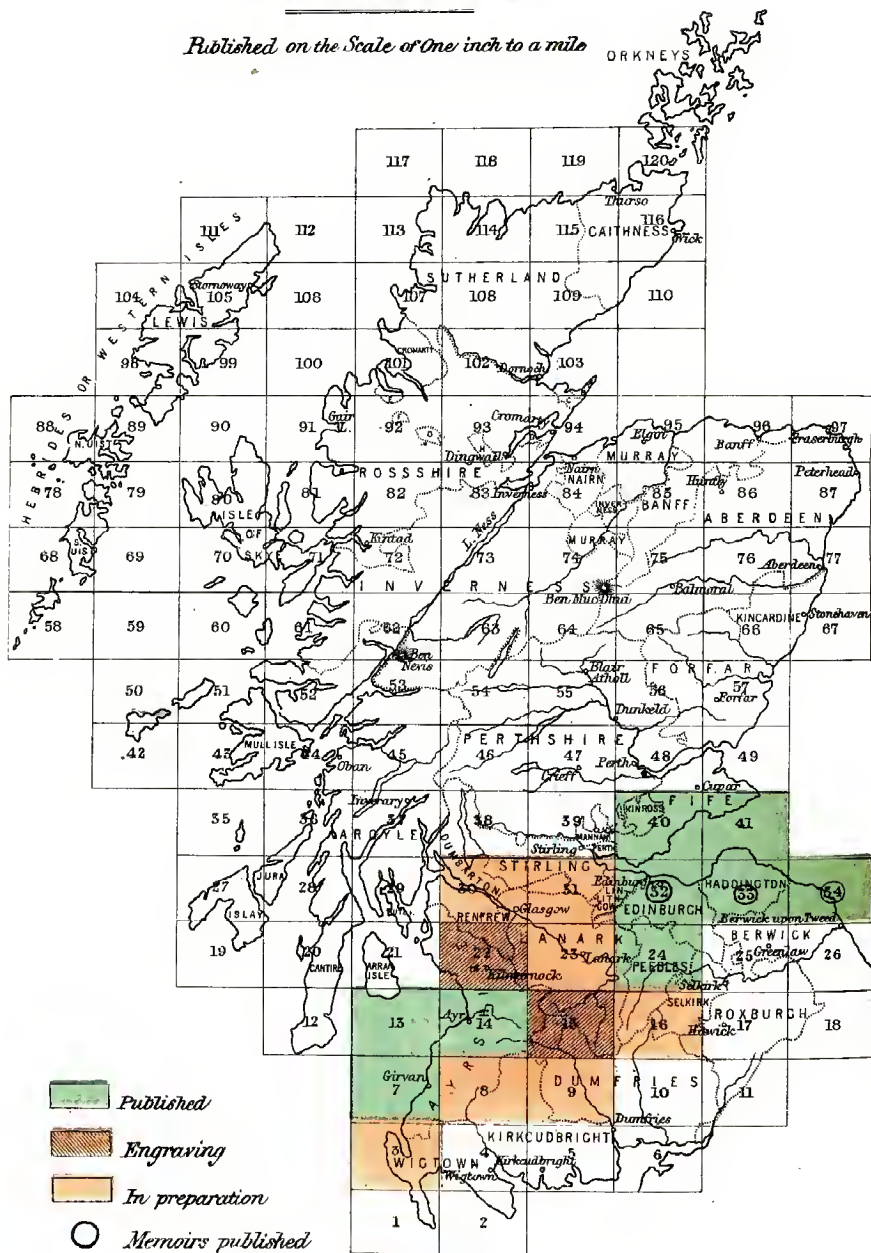






**INDEX**  
to the  
**GEOLOGICAL SURVEY MAP**  
of  
**SCOTLAND**

*Published on the Scale of One inch to a mile*





**Memoirs of the Geological Survey,  
SCOTLAND.**

**EXPLANATION OF SHEET  
7.**

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**AYRSHIRE: SOUTH-WESTERN DISTRICT.**

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**1869.**



## PREFACE.

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THE present sheet of the Geological Survey Map of Scotland was surveyed by Dr. John Young, Mr. James Geikie, Mr. B. N. Peach, and myself; Professor A. C. Ramsay being at the time Local Director of the work under the Director-General, Sir Roderick Murchison. My share of the mapping extends from the northern edge of the map southwards to a line drawn from the north flank of Pinbain Hill to Little Letterpin. Dr. Young mapped the ground immediately to the south of that line, as far as the Lendal Water and the Kinclaer Toll-bar. The remainder of the map to the south was surveyed by Mr. James Geikie, except the ground lying to the east of a line drawn from Dalreoch,  $1\frac{1}{2}$  mile E. of Colmonell, southward by Liglea in Glen Tig, to Drumbowie Rig, which was mapped by Mr. Peach.

The northern portion of the sheet, from Ballantrae to Girvan, forms part of the area described by Sir Roderick Murchison in 1851, and of which he published a Sketch-Map, in which this part of Scotland was first brought into general correlation with the Silurian rocks of Wales. (*Quart. Journ. Geol. Soc.*, vii. 139.)

Of the following Explanation, paragraphs 2, 4, 8-10, 17, 20, 25-28, 32, and 34, have been furnished by Mr. James Geikie, the rest have been written by myself. The lists of fossils have been prepared by Mr. Etheridge, Palæontologist to the Survey. It is proper to add, that the full details of the Survey of this district fall to be given in the Geological Survey's Memoir on the Geology of Ayrshire, which is in preparation.

ARCH. GEIKIE,  
*Director.*

GEOLOGICAL SURVEY OFFICE,  
EDINBURGH, *July* 1869.



# EXPLANATION OF SHEET 7.

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## I. AREA EMBRACED IN THE MAP.

1. This sheet of the Geological Survey Map of Scotland comprises the south-western maritime tracts of the county of Ayr from near Girvan to the mouth of Loch Ryan. Along the southern edge of the Map three small portions of Wigtonshire project to the northward; but, with these exceptions, the whole area belongs to the old division of Ayrshire known as Carrick. It includes the mouth of the Girvan Water, the valley of the Stinchar as far up as the confluence of the Assel, Glen App, the Water of Tig, and the upper streams which drain into the Water of Luce. The area included in the Map is about 110 square miles.

## II. FORM OF THE GROUND.

2. The physical features of this district present little variety. The country is hilly throughout, the only comparatively level tracts being the narrow strips which flank the principal streams. But although this is the general character of the region, yet, if we take the line of the River Stinchar, which flows south-west, we shall find that the ground to the north of this river is somewhat more diversified than the more elevated tract of hilly land to the south. This latter may be described as an undulating and sloping table-land, the axis of which runs N.E. and S.W. through Beneraird (1435 feet over the sea). Near the northern margin of the district, in the neighbourhood of Ballantrae, the ground (300 feet or thereby above the sea-level) begins to ascend gently at first for about a mile and a half, after which it rapidly slopes up from 400 or 500 feet to a ridge of hills (1200 feet) which overlooks the long straight valley of Glen App. The highest point in this district is reached in Beneraird, south of Glen App, from which point the ground slopes away to the south in a series of soft undulations. Nearly all this area is moor and pasture land, the cultivated tracts being almost exclusively confined to a few narrow bands along the course of some of the streams. The slopes of this undulating table-land seldom show any bare rock, but are abundantly coated with peat and coarse grasses, which gives a bleak and desolate aspect to the country. In the district north of the River Stinchar the ground does not attain a greater height than about 860 feet; but the surface generally wants the smooth undulation of the more elevated tracts towards the south, many of the hills being precipitous and abrupt, and showing numerous broken scours and crags of rock.

3. Two leading systems of valleys traverse the southern uplands of Scotland, and both are exhibited on the present Map. The one runs parallel with the general strike of the Silurian formations, that is, north-east and south-west; the other crosses the intervening ground transversely

in a general north-west and south-east direction. The former, or longitudinal series, is seen in the dominant valleys of the Girvan, Stinchar, and Glen App; to the latter, or transverse series, belong the numerous tributaries which flow from either side into these streams, as well as those which, rising on the table-land south of Glen App, flow down towards the Bay of Luce. With one exception, no connection has been traced between the direction of the valleys and the line of any faults among the rocks. The longitudinal valleys run more or less along the strike of the strata, but without adhering rigidly to one group of beds. The Stinchar, for instance, winds to and fro over unaltered, metamorphosed, or crystalline rocks, while at the same time it skirts, flows along for a little way, and then crosses lines of fault. The same features are exhibited by the Girvan. There can be no doubt, however, that the strike of the rocks has guided the course of these streams, and determined the parallelism of all the longitudinal valleys. The transverse valleys, on the other hand, are much more sinuous and irregular, and, so far as can be ascertained, bear little or no reference to the geological arrangement of the rocks beneath them. They wind across the edges of the highly inclined Silurian strata, very much as they would have done through any other group of rocks.

4. The one singular exception to the want of relation between the trend of the valleys and the line of the faults is furnished by Glen App. That valley coincides with the line of a fracture which has been traced from Finnart Bay for many miles inland. This dislocation everywhere gives rise to a marked feature even when the hollow is not occupied by a water-course. This is well seen in the present Map. From the head of the Water of App the depression or hollow is easily traced across the watershed into the Muck Burn. The peculiar straightness of the Glen App valley is quite abnormal, and serves to distinguish this from the other longitudinal valleys, where no connection can be traced with any fracture of the rocks underneath. As in the district south of the Stinchar, so here, agricultural operations are carried on chiefly in the valleys and along the coast-line, the remaining portions of the ground being in pasture land. The fertile fields, the fine banks of natural wood and other timber, and the comfortable farm-houses of the Stinchar valley, contrast strongly with the bleak stretches of moor and pasture land, and their lonely shepherds' cottages, immediately beyond.

5. The coast-line from the northern edge of the Map, southward to the mouth of the Stinchar, presents a narrow flat selvage of ground between the sea-margin and a steep bank which marks a former coast-line, and sweeps up into the hilly ground of the interior. In one or two places, particularly at Bennane Head, this level platform is interrupted by the projection of a bold headland into the sea. In such cases, the coast road which lies along the platform has to ascend and cross the interruption. South of the Stinchar, a line of broken cliff descends abruptly upon the sea all the way south into Loch Ryan, and the high road has therefore been diverted inland so as to reach the shore again by the valley of Glen App.

## 6. III. FORMATIONS AND GROUPS OF ROCK ENTERING INTO THE STRUCTURE OF THE DISTRICT.

### AQUEOUS.

Recent and Post-Tertiary.	{	Alluvium, Peat.
		Blown Sand.
		Raised Beaches.
		Glacial Drifts.

<b>Permian.</b>	Red Sandstone and Breccia.
<b>Old Red Sandstone (Middle).</b>	Red Sandstones and Conglomerates. { Lower Llandovery. { Caradoc. { Llandeilo.
<b>Lower Silurian.</b>	

#### METAMORPHIC AND IGNEOUS.

<b>Miocene (?)</b>	Dolerite dykes.
	{ Altered semi-crystalline strata, bedding still distinct in some parts. Felspathic and Porphyritic rocks.
<b>Associated with Lower Silurian rocks.</b>	
	{ Felstone. { Syenite. { Diorite. { Hypersthenite. { Diallage rock. { Serpentine.

### IV. GEOLOGICAL STRUCTURE OF THE DISTRICTS CONTAINED IN THE MAP.

7. With the exception of the two small patches of Old Red Sandstone towards the north-eastern corner of the sheet, and the little Permian outlier at Ballantrae, all the ground represented by the Map is occupied by rocks belonging to the Lower Silurian series. It will be seen that the course of the River Stinchar very nearly coincides with a marked line of division in this Silurian district. To the south the rocks are of the usual character which prevails among the uplands of the south of Scotland. But on the north side of the line these strata have been much metamorphosed, and they are pierced by intrusive masses of syenite, felstone, and diorite. Each of these two areas falls to be described separately.

#### Lower Silurian.

##### a. District South of the Stinchar Valley.

8. A large fault, with downthrow to the north, which runs parallel with the valley of the River Stinchar in a long sinuous line, from Brackness Hole on the sea-coast to Pinmore on the Stinchar (*i.e.* N.E. and S.W.), forms the northern boundary of this district. The strata consist of greywacke, conglomerate, shale, and occasional bands and beds of Lydian stone. They have not yet yielded fossils, except some obscure, possibly fucoidal, markings, but they are probably referable to some part of the great Llandeilo series.\* Greywacke is by far the most abundant kind of rock. It is commonly of a blue or bluish-grey colour, and varies in texture from a fine-grained mudstone to coarse-grained grit, which occasionally becomes pebbly and conglomeratic. These various kinds of greywacke occur in thick beds and thinner bands, which are usually much jointed; hence the rocks are not well adapted for building purposes. Occasionally, however, the joints are less plentiful, and the greywacke might be easily quarried; but the want of good roads, and the distance from railways, render these rocks, save for local purposes, practically valueless. The greywackes are interbedded with lines, partings, bands, and beds of shale, usually hard, shattery, fine-grained, greyish-blue,

\* At Cairn Ryan, which lies a little to the south-west, on the same line of strike, Mr. J. Carrick Moore found *Graptolithus folium*, *G. pristis*, *G. tenia*, etc. See *Quart. Journ. Geol. Soc.*, vol. v. p. 13; Murchison, *Siluria*, 4th ed. p. 155.



grey, or green. In some places these show a rude cleavage, but this is not common; they are nowhere rendered suitable for roofing purposes. Bands of coarse conglomerate occur here and there, and one great mass occurs on the north side of the Glen App fault, forming the hills of Auchencrosh and Smirton, Balragie Fells, etc. Another mass of conglomerate, on the same strike, forms the bold headlands between Corsewall Point and Millour Point, in Wigtonshire. The nature of the stones in these conglomerates, and their great size, render this deposit sufficiently remarkable. The stones and boulders consist principally of syenite, gneiss, granite, various porphyries, felstone, quartz rock, quartz, greywacke, etc., and they vary in size from mere pebbles up to blocks four and five feet in diameter. The general character of the deposit is that of a coarse boulder conglomerate, in which sometimes all trace of bedding is lost. No metamorphic nor igneous rocks from which the boulders in this conglomerate could have been derived, exist in the neighbourhood; nor indeed do such rocks of pre-Llandeilo age occur nearer than the Laurentian rocks of the north-western Highlands and islands of Scotland. Possibly the boulders may have come from some ancient Atlantis; and considering the great size of many of the blocks, and the considerable distance they may have travelled, it is not unreasonable to conjecture that ice may have had something to do with their transport. No ice-markings, however, were observed upon any of the stones; nor, when we reflect upon the vast age of this deposit, could these be expected to have resisted the long-continued action of percolating waters.

9. The general strike of the rocks of the district is N.E. and S.W., and the strata are almost always inclined at high angles. The beds have, on the whole, a prevailing dip towards the south-east; but immediately south of Colmonell it will be seen, from the opposing dips indicated upon the Map, that the strata are in fact arranged in synclinal and anticlinal folds. Even when the dip is persistent for several miles towards the south-east, this need not imply a vast thickness of strata, for the beds may simply be thrown back upon each other in a series of rapid folds, the tops of the arches or curves having been removed by denudation. Thus the same beds may again and again appear. Some magnificent examples of contorted strata occur in the bold sea-cliffs between Downan Point and Finnart Bay. In some places the greywackes are curiously honeycombed with circular and oval cavities, the origin of which does not appear evident. They may perhaps denote the former presence of something organic. Ripple marks have been observed upon the surfaces of some of the fine-grained greywackes, but they are not very common.

10. The Silurian strata of the district, as indicated on the Map, are traversed by dykes or veins of intrusive rocks. These generally run along the prevalent line of strike, and present much the same petrographical characters as the similar intrusive rocks which are met with in the Silurian uplands of the south of Scotland. The most common variety is a pinkish, finely crystalline or compact felstone, porphyritic with crystals of felspar, and sometimes containing clear quartz in globules scattered through the matrix. Dykes of dark-coloured diorite also traverse the Silurian strata in some places; they coincide in direction with the felstone dykes just described, and must be distinguished carefully from the later set of dolerite dykes, to be afterwards referred to.

### **b. District North of the Stinchar Valley.**

11. Between the two Silurian districts which are divided by the line of the Stinchar valley, there is as much diversity in geological structure as

there is in external outline. To the north of that valley the Silurian rocks appear to belong almost entirely to the Caradoc group, though some portions south of Girvan may perhaps be referable to the Lower Llandovery group. The structure of the ground, however, is exceedingly complicated, and cannot be adequately described, without taking in the district to the east, which will be elucidated in the explanation to Sheet 8. Over and above their foldings and fractures, the rocks have been to a large extent, and over a considerable area, metamorphosed.

12. Where the metamorphism and the intruded crystalline rocks are absent, the strata are found to consist of greywacke, shale, conglomerate, and limestone. Of these the limestone is the most important member, inasmuch as it contains fossils, from which the Caradoc horizon of the strata is determined. It is a white or grey compact amorphous rock, occurring in large lenticular masses, and usually associated with coarse conglomerates, which sometimes both underlie and overlie it. It is well exposed in the large quarries at Aldons; smaller portions occur at Little Letterpin and Pinnacher. East of these localities, it forms large masses between the valleys of the Assel and Stinchar. In the metamorphic tracts also a number of exposures of limestone have been noted, as shown upon the Map. Though surrounded now by more or less crystalline altered rocks, there can be no doubt that these latter areas of limestone, as shown by their fossils, belong to the same series as the limestones to the north-east.

### 13. *Fossils from the Limestone at Aldons.\**

Cytheropsis Aldensis.	Turbo ?
„ sp.	Murchisonia large sp. new.
Maclurea Logani.	Holopea ?
„ magna.	Bellerophon.
Raphistoma ?	

14. The conglomerates form a very marked feature among the Caradoc rocks of this region. They give rise to bold craggy hills, of which examples are furnished by the Dinvin Hill, Glendrissock Hill, and the Byne Hill; or, when in smaller mass, they stand out as a rough top to a smooth-sloped eminence,—as in the Dow Hill, to the south of Girvan. Usually they are very coarse in texture, their well-rounded stones consisting of syenite, quartz, porphyry, feldstone, greywacke, serpentine, etc. As a rule, bedding is either absent, or can only be indistinctly made out. Where, however, the stones are smaller in size, the conglomerates become distinctly bedded, and pass off into mere pebbly grits. The matrix varies in colour from a dirty brown to a dull green, the latter being the prevailing colour to the east of the present Map. In texture the paste is sometimes coarse and granular, sometimes fine-grained; and occasionally so hard, that, as in the Byne Hill, the smooth casts of the stones are preserved in it long after the stones themselves have fallen out.

15. In the area embraced by the present Map, the only locality where a continuous intelligible section can be followed for some distance, is along the coast-line between Girvan and Kennedy's Pass. On the beach at Shalloch, beds of very coarse conglomerate, greywacke, and shale are found dipping to N.E., or standing on edge, and much contorted. A little farther south, beyond these disturbed strata, a series of beds begins at Shalloch Mill, and, striking south-westward nearly parallel with the coast-line, extends as far as the foot of Pinbane Hill, where the metamorphosed rocks commence. Along the beach from Shalloch Mill to Ardwell Bay, the dip is at high angles to S.E.; on the inland slopes behind Ard-

\* See the list from the Craighead limestone, in Explanation of Sheet 14 of the Geological Survey Map, par. 14.

millan, and thence along the shore to Kennedy's Pass, the dip is north-westward. Hence it would appear that the rocks here are disposed in a synclinal trough, the axis of which runs through Ardwell Bay. Along the south-eastern edge of this trough, a massive conglomerate rises from under the other beds, and stretches southwards until lost among the metamorphic rocks. Here and there, too, on the points of the farthest promontories, we find coarse conglomerate and pebbly grits rising from under the beds on the other side of the syncline. Above these lower strata there are exposed on the beach, beds of hard greywacke, shale, and pebbly grit. One zone of red and green shale is particularly observable. Throughout these beds, courses of nodular impure limestone, or cement-stone, frequently occur, and sometimes contain well-preserved fossils. The manner in which the beds are broken and twisted by small faults, can be readily examined on the beach, where also the numerous dolerite dykes, to be afterwards referred to, are well displayed. The shore to the south-west of Ardwell is occupied by a series of hard flagstones and flaggy shales, which are either vertical, or inclined at steep angles to N.W. They are frequently much twisted and broken, more particularly as they pass south-westwards. They lie directly upon the conglomerate of Kennedy's Pass. To the south of Ardmillan House, however, close to the northern margin of the conglomerate, certain beds of shale and greywacke were detected by the Geological Survey, from which a large suite of fossils was obtained.

#### 16. *Fossils Collected by the Geological Survey at Ardmillan Brae.*

Stenopora fibrosa.	Modiolopsis or Ambonychia.
Heliopora (Favosites).	Orthonota.
Petraia elongata.	
Illaenus Bowmanni.	Holopella ? sp.
Asaphus gigas ?	Holopea.
Stygma latifrons.	Raphistoma lenticularis.
Staurocephalus globiceps.	sp.
Phacops Brogniarti.	Murchisonia.
Dalmanni.	Maclurea.
Bronteus Hibernicus.	Cyclonema crebristria.
	Ophileta compacta.
Orthis elegantula.**	Conularia elongata.
calligramma.	Theca reversa.
"                                var. virgata.	triangularis.
sp.	vaginala.
Rhynchonella (Retzia) cuneata.	sp.
Leptaena tenuicincta.	Ecculiomphalus minor.
sericea.**	sp.
? sp.	Scoticus.
Strophomena grandis.**	
arenacea.	Bellerophon acutus.
Discina laevigata.	carinatus.
"                                var.	trilobatus.
Cucullella or Arca.	Orthoceras imbricatum.
Otenodonta.	ibex.
Modiolopsis.	sp.

\* \* Species marked with asterisks are particularly abundant at this locality.

17. The metamorphic rocks of this district, although numerous and varied in character, may yet be conveniently grouped into three classes—Felspathic Rocks, Diorites, and Serpentine. These masses usually occur in belts or bands, agreeing in general dip and strike with the surrounding unaltered strata. The chief interest which is attached to the altered strata of this district consists in the fact that they exhibit certain arrested stages of metamorphic action, so that we can in many instances begin with unaltered beds, and trace their gradual passage

into crystalline rocks, which cannot be distinguished from those which have had a true igneous origin. The *Felspathic rocks* are by far the most abundant, and vary much in structure and aspect. A common character among them is that of a dull, compact, sparingly porphyritic rock, and much resembling many of the true porphyrites of the Old Red Sandstone. The more crystalline rocks belonging to this division are indicated in the Map by a dark tint, and lettered F—the pale shade of carmine, lettered 'β', representing those portions of the strata which are less crystalline, and in which the original character of the strata may not unfrequently be observed. The *Diorites* and *Serpentines* have a more definite character than the last mentioned group of rocks, and are often interbedded, or very closely associated. The former (*Diorites*) are expressed in the Map by the dark shade of carmine, with white stippling, while the *Serpentines* are marked out by green wavy lines on a pale carmine ground. A glance at the Map will show that all these rocks stretch across the district in a series of alternate bands from south-west to north-east, thus corresponding with the general strike of the Silurian strata. Their northern boundary will also be seen to be exceedingly irregular, portions of the crystalline masses stretching out into the unaltered strata, while faults and overlaps of Old Red Sandstone add still more to the confusion. The detailed structure of this interesting region will be described in the Geological Survey's *Memoir on the Geology of Ayrshire*. The following table of the more important rocks, and the localities where they are best seen, may in the meantime be of service:—

#### a. Felspathic Rocks.

1. Amygdaloidal.	Localities.
a. Granular strata, with scattered patches having a vesicular structure.	Between Balcreuchan Port and Port Vad.
b. Amorphous, dirty-green and brown rocks, with bomb-like patches of amygdaloid.	Between Balcreuchan Port and Port Vad.
c. Amygdaloid, with spherical cavities.	Coast between Knockgowan Hill and the mouth of the Stinchar; also at many points on the shore north of Bennane Head.
2. Felspar Porphyry.	Shore, foot of Balcreuchan Burn; Knockgowan Hill; etc.
3. Brecciform Rocks. Many of these are altered conglomerates.	Shore near Bennane Head, Knockdolian Hill.
4. Finely-crystalline Rocks.	Various parts of shore north of Bennane Head.

#### b. Dioritic Rocks.

1. Diorite.	Balsalloch, Carleton, Lendalfoot, Fell Hill, etc.
2. Syenite.	Byne Hill, Ailsa Craig.
3. Hypersthenite.	Shore at Lendalfoot.
4. Diallage Rock.	Shore at Lendalfoot.

#### c. Serpentine, etc.

1. Serpentine.	Shore at Lendalfoot; Balhemie Hill; hills from Leudalfoot to the Byne Hill.
2. Altered Limestone. Often very serpentinous.	Shore near Pinbane, Laffincleary; Whilk; Bennane Head; Knockdolian Hill; Knockdolian Bridge; etc.

18. Ailsa Craig is an oval-shaped island, lying ten miles west from Girvan. Its extreme height is 1113 feet, its longer (or N. and S.) diameter is about 1500 yards, and its shorter (or E. and W.) diameter, from 1000 to 1250 yards. It rises nearly vertically from the sea, on all sides except the east. There a triangular patch of low shingly ground intervenes between the base of the steep eastern declivity of the island and the waves. The Craig consists of a grey fine-grained syenite, which, on the southern and western precipices, shows a system of close, parallel, vertical joints, by which a columnar aspect is given to the rock. Though no Silurian strata are visible here, there is every reason to believe that this syenitic mass rises among rocks of that age, resembling in this respect, as well as to some extent also in petrographical character, some of the crystalline rocks which rise through the Silurian strata of the south of Ayrshire. Dykes of dolerite run in a north-westerly direction through the syenite. These belong to the late series referred to in par. 21. One of the most interesting features on Ailsa Craig is seen in its parallel lines of shingle, marking successive stages in the advance of the coast. (See par. 33.)

### Old Red Sandstone.

19. Two areas of red sandstone and conglomerate are marked upon this Map. One of these is cut through by the lower reaches of the Girvan Water, and forms a continuation of the Middle (?) Old Red Sandstones which stretch northwards to near the Heads of Ayr, and eastwards to Maybole and the Doon. These strata are more fully described in the Explanations of Sheets 13 and 14. The second area lies as a small outlier in the valley of the Bynhill Burn, a little to the south of Girvan. That this outlier belongs to the Middle (?) Old Red Sandstone series is inferred both from its proximity to the members of that series, so well seen on the hills to the south of the Girvan Valley, and thence northward to near the mouth of the Doon, and from the similarity of its beds to those of these adjoining tracts. As indicated on the Map, the existence of the outlier has been largely determined by a series of faults, by which the newer strata have been thrown in among the Silurian rocks. On the southern margin of the outlier, however, we meet with its lowest beds, lying unconformably upon and made up from the waste of the older formation. These bottom strata dip, on the whole, in a more or less northerly direction, and this continues to be the prevalent inclination throughout the length of the outlier. The angle varies from  $5^{\circ}$  up to  $60^{\circ}$ , or even to  $90^{\circ}$ . The strata consist chiefly of dark red sandstones, sometimes passing into a dirty-green tint. Along with these, there occur several thick zones of conglomerate, which, in its higher beds, is reddish in colour, and consists chiefly of different fragments of red greywacke. Towards the base of the series, however, the tint becomes greenish; and as these conglomerates have been derived from the older Silurian conglomerates, they are sometimes hardly distinguishable from the latter, more especially where they have been thrown into a vertical position. In the stream between the two farms of Drumfairn and Cairntop, conglomerate is seen resting upon and made up of the green serpentine rock of the metamorphic Lower Silurian series. The metamorphism, therefore, is here older than a part of the Middle (?) Old Red Sandstone. In the Byne Hill Burn, from the farm of Balkeachy to Byne Hill Bridge, and also in several of its tributaries between these two points, excellent sections of the sandstones and conglomerates are exposed.

## Permian.

20. To this formation is assigned a set of thin-bedded red sandstones, only seen along the coast between Ballantrae and Bennane Head. These strata frequently show ripple-marked surfaces, and rain-prints have been observed upon them. At the pier, Ballantrae, they contain a red breccia. From that point to where they cease, near Bennane Head, they have a general northerly dip, with an average angle of from  $8^{\circ}$  to  $15^{\circ}$ . As their beds must be truncated against the bank of older rocks, which rises inland from the coast-line, it is believed that they are faulted down in the manner shown upon the Map. The Permian age of these strata is inferred from their resemblance to the Permian sandstones which overlie the coal-field of Ayrshire. They are cut through by dykes of dolerite, which may be seen upon the beach.

## Miocene (?).

21. Later than all the rocks described in the foregoing paragraphs comes a series of dolerite dykes. These preserve a prevalent north-westerly direction, with which they cross the older formations, irrespective of strike, dip, joints, or even of faults. Good examples are shown on the beach to the south-west of Girvan, where the dykes cut through highly inclined Lower Silurian greywacke and shale. Farther south similar dykes traverse the metamorphosed rocks, while near Ballantrae they rise through the Permian sandstones. The rock of which these dykes consist is usually a fine-grained dolerite, sometimes dull, earthy, and decomposing, and sometimes with lines of vesicles running parallel with the sides of the dyke.

22. These dykes are not confined to this district. They abound over the south and west of Scotland, and are connected with the great doleritic plateaux of Antrim and the Inner Hebrides. As the latter are undoubtedly of Miocene age, the dykes which diverge from them are referred to the same date. (See Explanation of Sheet 14, par. 63, and references there given.)

## Faults.

23. All the large faults in the area embraced by the present Map run from S.W. to N.E., which is likewise the prevalent direction of the greater dislocations throughout the southern half of Scotland, as well as the chief line of strike of the geological formations throughout Great Britain. The parallelism of these fractures is shown on the Map. Thus, from the mouth of Glen App a fault has been traced for many miles inland, with a singularly unbending north-easterly trend. Farther north lies the fault already referred to, which, by a downthrow to the north, brings down the higher and metamorphosed parts of the Lower Silurian series against the Llandeilo rocks. This and another dislocation seem to come together near Aldons, whence a marked fault extends in the same line for many miles up the south side of the Stinchar Valley. The two chief faults which bound the Old Red Sandstone outlier south of Girvan have approximately the same trend; while a little farther north we find the south-western extremity of a large fault which bounds the Silurian district on the north-west. Numerous minor faults, as shown on the Map, diverge from the main line of the great fractures.

## Glacial Drifts.

24. Carrick, of which the area embraced in the present Map forms the south-western extremity, is the north-western part of the mountainous

region which stretches from Nithsdale to Loch Ryan and Luce Bay. Its hills and valleys diverge from high grounds which served as an independent centre of dispersion for the ice of at least the later stages of the glacial epoch. Hence the markings which have been left upon its rocks bear witness to the movement of thick masses of ice from these high grounds outwards into the Irish Channel. In the valleys they run along the hill-sides, indicating that the valleys served formerly to drain off the ice as they now drain off the water. But that the ice was in mass sufficient not only to fill the valleys, but to mount over the intervening ridges, is well shown on the range of hilly ground between the Stinchar and the Girvan. There the striæ on the rocks look directly up to the great Galloway uplands. The knolls have still the characteristic forms of *roches moutonnées*, even where the striæ have been effaced by time. This is admirably seen in the hollow of the ridge between the Fell and Byne Hills above Ardmillan House, where the well ice-worn hummocks of diorite still retain in places their striæ pointing to W. 5° N. Where the coast-line is low, the striæ on the rocks retain the direction with which they have advanced from the interior. This is well shown on the beach at Shalloch Mill, where, under a recently removed covering of boulder clay, the fine grey Silurian shales retain the ice-groovings which strike W. 5° N. When, however, the ground rises more steeply from the sea, the trend of the striæ corresponds, on the whole, with that of the coast-line. Examples of this relation are seen on the flanks of Pinbane Hill, at Downan Point, and a little south of the shore end of the Stinchar fault. From these facts it appears that the low ground now covered by the Firth of Clyde was filled with ice moving steadily southward, and that into this main sheet there flowed thick masses which descended along the valleys from the high lands of Carrick and Galloway.

25. The Drift of this hilly district presents many features of interest which cannot properly be described without reference to the ground to the east (Sheet 8). There are two boulder clays, a lower and an upper deposit. The lower boulder clay, usually concealed below the overlying drift, is for the most part only to be seen in stream cuttings when these go deep enough. Its usual character is that of a stiff, tenacious, light-brown, and sometimes greenish-grey clay, thickly set with numerous well striated and polished stones. These have been exclusively derived from the rocks of the district. Between this deposit and the upper boulder clay, beds of earthy gravel and sand occasionally occur. The upper boulder clay is generally of a dirty-brownish colour. The stones with which it is charged, although often well scratched and smoothed, yet, as a rule, are larger, more angular, and less polished than the corresponding stones in the lower deposit. It is frequently rudely stratified, containing gravel and sand, and 'guttapercha' clays in places. Even where such intercalated beds are absent, lines of stones can frequently be traced. Many large boulders occur in this drift, which often appear to pass into a coarse shingle and boulder gravel, closely resembling moraine matter in character. This latter kind of drift is abundantly scattered over the hilly grounds south of the Stinchar valley, where it is occasionally heaped up into mounds. It is in the valleys where the stratified character of the upper drift is most apparent. A fine section of stratified upper boulder drift is seen in the old sea cliffs near Bennane Head, where the sandy beds have yielded comminuted fragments of shells.

26. Kames of sand and gravel have been observed a little north of Knockdolian Hill; mounds of coarse gravel and angular débris also occur here and there along the northern flank of the Auchencrosh Hills. These mounds, and probably the kames at Knockdolian also, appear to be connected with the upper boulder clay. The drift generally lies thickest



in the valleys, appearing only in a sparse and scattered manner upon the hill-tops, where, however, it often attains a considerable thickness, especially in the hilly region south of the Stinchar.

27. Erratic blocks are very numerous, and often attain a great size. Several very large boulders of greywacke and other Silurian rocks occur at Pyell Craig, on the north bank of the Stinchar between Ballantrae and Colmonell. One of these, called the 'Cloven Craig' (forming one of a stream of boulders), is a great mass split along the joints into three main fragments. The largest fragment must contain upwards of 2500 cubic feet, and the other two portions are not much smaller. Granite boulders brought from the mountains round Loch Doon abound. They are particularly numerous in the valley of the Girvan, and on the beach north of the mouth of that stream.

### **Raised Beaches.**

28. Traces of old coast-lines at a higher level than the well-marked 25-feet raised beach are seen at Girvan and Ballantrae; at the latter place two such higher terraces are seen, the lower being 50 feet, and the higher 75 feet above the sea. On the side of Downan Hill, at the mouth of the Stinchar, several high-level ledges have been excavated on the slope; but these are only seen when looked at from some little distance. The highest of these ledges is about 300 feet above the sea. The rocks are, however, so much broken up and weathered, that the terraces, on a closer inspection, can hardly be traced. They are best seen from a point a little way up the valley of the Stinchar.

29. On the north side of the Girvan, a little above its mouth, there are traces of a terrace which may represent the 40-feet beach of the west of Scotland. Fragments of what seems to be the same terrace are found farther south, near Shalloch Mill, and at Ardmillan.

30. The 25-feet raised beach forms one of the most marked features of the coast scenery of this district. From Girvan to Ballantrae it runs along the coast-line as a narrow strip of flat meadow land, from the inner margin of which, representing the former coast-line, the hills rise abruptly into the interior. This terrace has here usually been cut out of boulder clay, as is well seen at Girvan, and thence southwards to Kennedy's Pass, at Lendalfoot and Ballantrae; in other parts of its course it has been excavated in solid rock. At one or two places between Girvan and Ballantrae the terrace is interrupted by the advance of the high grounds into the sea. At Bennane Head, for example, an interruption of this kind takes place, but the beach immediately recommences on the other side.

### **Blown Sand, Shingle Beaches.**

31. Patches of blown sand occur at Girvan, Lendalfoot, and Ballantrae. These have to some extent spread over and heightened the 25-feet raised beach, as has likewise happened along the rest of the Ayrshire coast-line to the north. They form mounds and ridges, which are covered over with coarse grass, and eventually converted into pasture land.

32. At the mouth of the Stinchar no blown sand is formed, as the whole flat there is liable to be flooded by the river after unusually heavy rains. It may be mentioned here, that, since the publication of the Ordnance Survey Map, in 1859, the Stinchar has opened for itself a new mouth through the high gravel bar which at this point stretches along the coast, the old mouth being now closed.

33. On the east side of Ailsa Craig a low triangular piece of ground lies at the base of the cliffs. This consists of coarse shingle, which has





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